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Working with:

Spiral Cellars

Your structural calculations from

ed

Installation of Spiral Cellar

Structural Calculations

Client: **Mr. & Mrs. Edelmann**

Site address: **19 Well Road,**
Hampstead,
London,
NW3 1LH

Job Ref no: **2019-224**

SO/SC-2696

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Contents:

White Wine Cellar Visualisation

Spiral Cellars

Telephone: 0845 241 2768

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Web: www.spiralcellars.com

Design Criteria Summary for Wine Cellar.

Project Description:

The project involves the design and subsequent installation of a Spiral Wine cellar. From previous experience the dominant load case for the design of this type of cellar is from water uplift pressures (to accommodate existing and future ground water levels) and as a result governs the wall thickness of the cellar with a minimum of 150mm required to create enough total mass to counteract the water uplift pressure.

A fibre additive (Strux) is used when mixing the 150mm wide concrete ring which controls cracking to the concrete and also creates inherent strength to the concrete ring (please refer to appendix for Strux certification, Strux is compliant with both the British Standards and Eurocode for fibres used in concrete design and specification covered by BS EN 14889-2 2006).

With the 150mm minimum ring thickness already established we then analyse the cellar for the following load conditions.

- Lateral loading from the existing structures foundations.
- Loading from ground floor structure and its finishes.
- Surface temporary surcharge loadings.
- Vehicle Loadings if deemed necessary.

Foundations close to the cellar produce a lateral load on the concrete ring which decrease the further away the foundation is from the cellar. We have analysed this for a worst case scenario of the foundations being placed 150mm from the edge of the cellar. This has also been analysed for combinations of walls placed on different sides.

Loadings from ground floor structures, temporary surcharges and vehicle loadings have also been analysed, again for worst case scenarios.

These worst case calculations have shown that the 150mm wide concrete ring required to avoid water uplift has, as a result of the Strux additive, excess lateral load carrying capacity. The following calculations demonstrate that the cellar can safely accommodate loading of up to 150 Kn/m^2 from a foundation placed up to 150mm from the edge of the cellar.

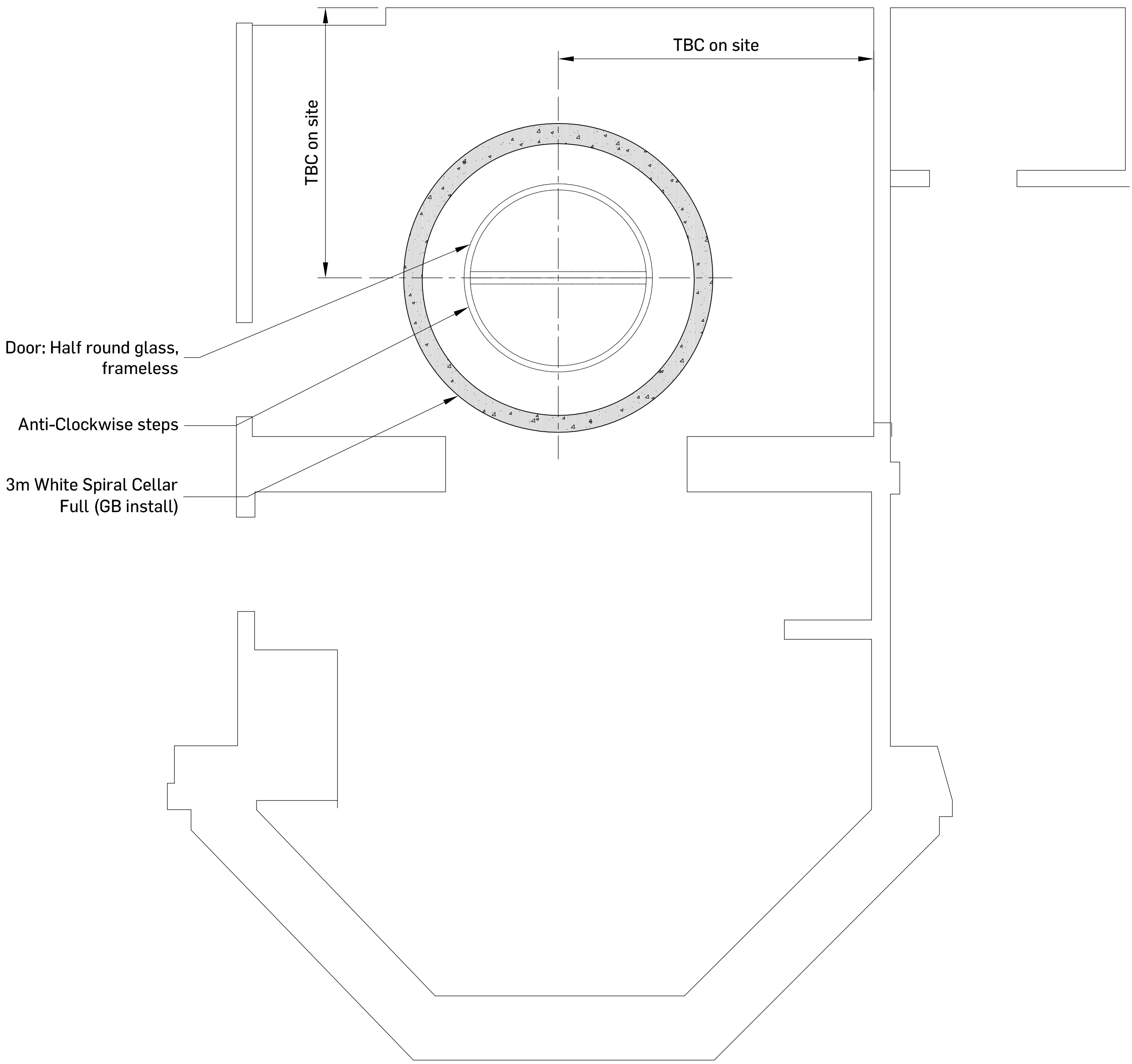
Several potential scenarios are checked for in the proceeding calculations which may differ from what is eventually built on site. This is done to ensure flexibility exists with our design for the cellar should certain alterations to the structure as currently proposed be carried out.

Job no: 2019-224
SO/SC 2696

INSTALLATION DETAILS

Address
19 Well Road, Hampstead,
London NW3 1LH

Name
Mr. & Mrs. Edelmann



Exact location for Spiral Cellar to be confirmed on site.

This is a generic drawing and should be read with Spiral Cellars Ltd details.

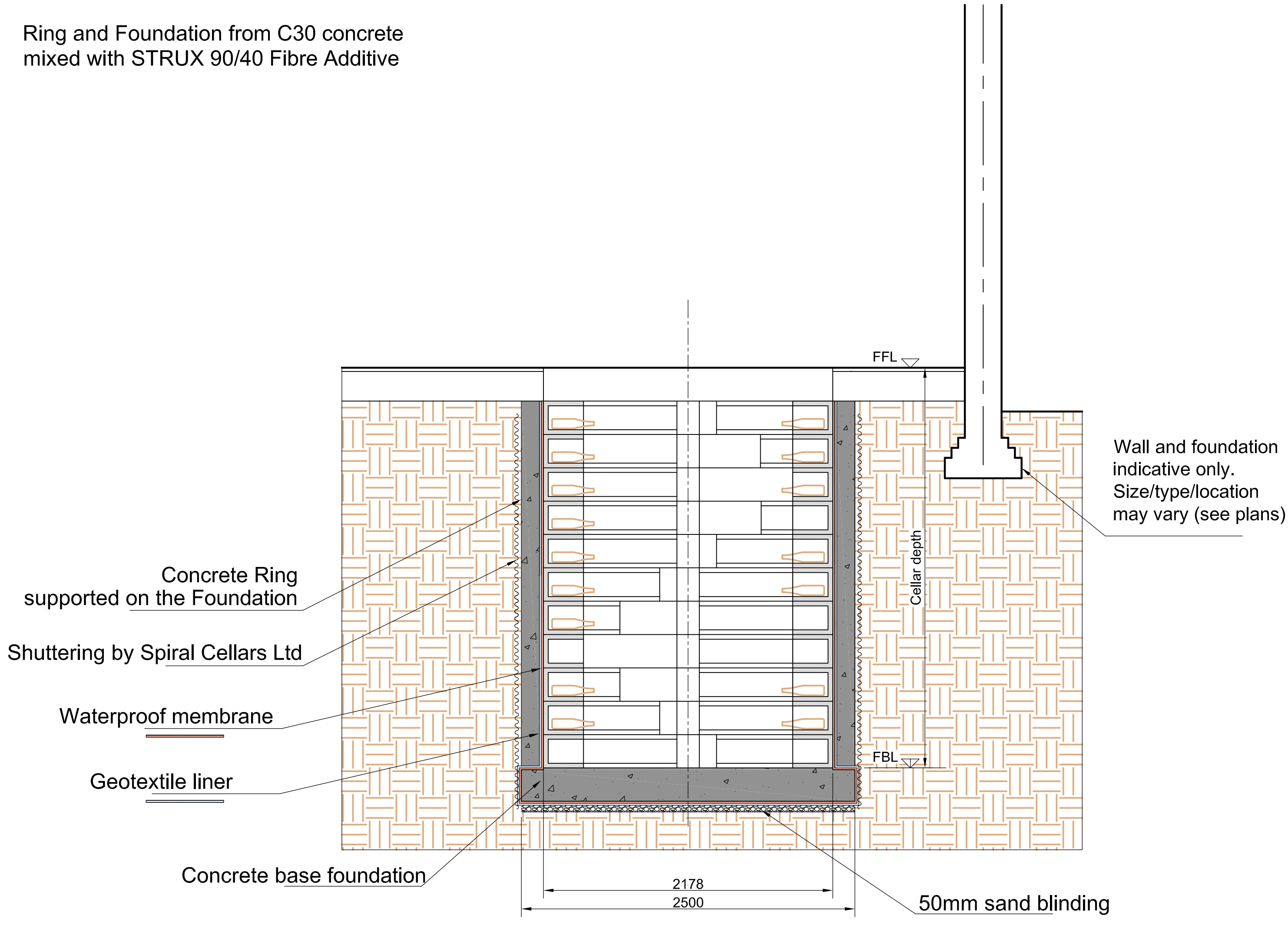
Refer to Architect's plans for details

SUMMARY SHEET

Address
19 Well Road, Hampstead,
London NW3 1LH

Name
Mr. & Mrs. Edelmann

Ring and Foundation from C30 concrete mixed with STRUX 90/40 Fibre Additive



NOTE:	WHITE SPIRAL CELLAR	
Spiral Cellar Internal Diameter	2.178m	
Spiral Cellar External Diameter	2.5m	
Spiral Cellar Depth from FFL to FBL	3.0m	
Excavation depth from FFL	3377mm	Confirmed by Project Manager
Base Concrete Thickness	250mm	not less than
Ring Concrete Thickness	150mm	not less than
Concrete Strength	30N/sqmm	For mixing details see Appendix 3
Concrete Fibre Additive	STRUX 90/40	For details see Appendix 2
Volume of Concrete Fibre Additive	5kg/cubic meter	For manufacturers specifications
Maximum Bending Moment	2.67 kNm	See Appendix 1
Maximum Bending Strength of Concrete with Fibre Additive	5.63 kNm	See Structural Calculations for Concrete Design

This is a generic drawing and should be read with Spiral Cellars Ltd details.

Impact Statement for Spiral Cellar design and installation

Design of the spiral cellar has taken into account lateral loadings from adjacent soil and foundations, which proved that the proposed structure is capable of resisting the occurring forces without negative impact to the building structure.

The installation process has to be undertaken according to the Method Statement provided by Spiral Cellars Ltd and followed by good building practice, which is essential to avoid harm to the existing building. For queries regarding the Method Statement please contact Spiral Cellars Ltd (Tel: 0845 241 2768).

Structural Calculations: 19 Well Road, Hampstead, London, NW3 1LH

Reference should be made to Elite Designers Ltd sketches for structural details and layout drawings.

Loadings from BS648 & BS6399 : Part 1 : 1984

Dead Loads - please note: these are general loads which may not be directly shown in the following calculations.

Ceiling	Thermal Insulation	$c_1 := 0.01 \cdot 10^3 \cdot newton \cdot m^{-2}$	
	Ceiling Joists	$c_2 := 0.16 \cdot 10^3 \cdot newton \cdot m^{-2}$	
	Plaster Skim	$c_3 := 0.03 \cdot 10^3 \cdot newton \cdot m^{-2}$	
	Plaster Board	$c_4 := 0.11 \cdot 10^3 \cdot newton \cdot m^{-2}$	
	Total Ceiling Load	$C := c_1 + c_2 + c_3 + c_4$	$C = 310\, m^{-2} \cdot newton$
Flat Roof	Asphalt 2 layers 19mm	$r_3 := 0.41 \cdot 10^3 \cdot newton \cdot m^{-2}$	
	Joists with decking	$r_4 := 0.25 \cdot 10^3 \cdot newton \cdot m^{-2}$	
	Total Ceiling Load	$R_2 := r_3 + r_4 + C - c_2$	$R_2 = 810\, m^{-2} \cdot newton$
Roof 30deg Pitch	Slate Tiling	$r_1 := 0.5 \cdot 10^3 \cdot newton \cdot m^{-2}$	
	Roof Rafters	$r_2 := 0.16 \cdot 10^3 \cdot newton \cdot m^{-2}$	
	Total Roof Load	$R_1 := r_1 + r_2 + C - c_2$	$R_1 = 810\, m^{-2} \cdot newton$
Wall Loads	Stud, Lathe and Plaster	$w_1 := 0.76 \cdot 10^3 \cdot newton \cdot m^{-2}$	
	Brick 255mm cavity	$w_2 := 3.76 \cdot 10^3 \cdot newton \cdot m^{-2}$	
	Brick 9" solid	$w_3 := 5.33 \cdot 10^3 \cdot newton \cdot m^{-2}$	
	Brick 13" solid	$w_4 := 7.69 \cdot 10^3 \cdot newton \cdot m^{-2}$	
	Foundation Wall Loads	$w_5 := 2.54 \cdot 10^3 \cdot newton \cdot m^{-2}$	

Floor Loads — 200x50 Joists With Decking — $f_1 := 0.25 \cdot 10^3 \cdot newton \cdot m^{-2} + c_1 + c_3 + c_4$

$f_1 = 400\, m^{-2} \cdot newton$

Foundation — Depth&Breadth — $D := 0.4m$ $B := 0.6m$

Concrete load — $Q_c := 24 \cdot 10^3 newton \cdot m^{-3}$

Imposed Loading - please note: these are general loads which may not be directly shown in the following calculations.

Floor Load Table 5 BS6399 — $I_{fl} := 1.5 \cdot 10^3 \cdot newton \cdot m^{-2}$

Floor Load Garage — $I_{flg} := 2.5 \cdot 10^3 \cdot newton \cdot m^{-2}$

Roof Load — $I_{rl} := 0.6 \cdot 10^3 \cdot newton \cdot m^{-2}$

Safety Factors

Live Load Safety Factor γfl — $\gamma fl := 1.6$

Dead Load Safety Factor γfd — $\gamma fd := 1.4$

Loads from FOUNDATION

For the worst case loading scenario, pressure under foundations was assumed to be 150kN/m^2 which is maximum that can occur in standard terrace house up to 4 storeys plus basement.

Uniform Load — $UL1 := 150 \cdot 10^3 \cdot newton \cdot m^{-2}$

Cellar Properties

Height of circular wall in meters — $D_w := 3$

External Radius of Circle in meters — $r := 1.25$

List of Soil Properties & Vertical Pressures

Soil pressure due to "Structural Foundation Designers" Manual by Curtins

Internal angle of friction — $\phi := 30 \cdot deg$

Density of soil — $\gamma := 20 \cdot 10^3 \cdot newton \cdot m^{-3}$

Density of water — $\gamma_w := 10 \cdot 10^3 \cdot newton \cdot m^{-3}$

Surcharge pressure from Live Load — $q_1 := 1.5 \cdot 10^3 \cdot newton \cdot m^{-2}$

Surcharge pressure from concrete floor — $q_2 := Q_c \cdot 0.15m$ — $q_2 = 3.6 \times 10^3\, m^{-2} \cdot newton$

Surcharge pressure from vehicles not exceeding 2.5 tons — $q_3 := 10 \cdot 10^3 \cdot newton \cdot m^{-2}$

Coefficient of active earth pressure $K_a := \dfrac{1 - \sin(\phi)}{1 + \sin(\phi)}$ $K_a = 0.333$

Lateral Surcharge pressures acting on the structure depending on position

From Live Load $\sigma_{ha1} := K_a \cdot q_1$ $\sigma_{ha1} = 500\,m^{-2} \cdot newton$

From Floor $\sigma_{ha2} := K_a \cdot q_2$ $\sigma_{ha2} = 1.2 \times 10^3\,m^{-2} \cdot newton$

From Vehicles $\sigma_{ha3} := K_a \cdot q_3$ $\sigma_{ha3} = 3.33 \times 10^3\,m^{-2} \cdot newton$

Lateral Surcharge pressure from soil and water

For finite element calculation purpose the loads were calculated as acting on 0.5 sqm areas of the structure depending on the depth.

Lateral Soil pressure at the bottom of the cellar $\sigma hS := K_a \cdot \gamma \cdot D_w \cdot 1m$ $\sigma hS = 2 \times 10^4\,m^{-2} \cdot newton$

Lateral Soil pressure @ 0.5m^2 plate area $\sigma_{hs} := \sigma hS \cdot 0.5$ $\sigma_{hs} = 1 \times 10^4\,m^{-2} \cdot newton$

Lateral Water pressure at the bottom of the cellar
Water surface assumed @ 0.75 cellar depth $\sigma hw := \gamma_w \cdot (D_w \cdot 0.75) \cdot 1m$ $\sigma hw = 2.25 \times 10^4\,m^{-2} \cdot newton$

Lateral Water pressure @ 0.5m^2 plate area $\sigma_{hw} := \sigma hw \cdot 0.5$ $\sigma_{hw} = 1.125 \times 10^4\,m^{-2} \cdot newton$

Lateral Soil pressure dependent on depth

Amount of the 0.5m^2 panels in height of the cellar - Ne and ratios for position of the centers of panels - he

$P_h := 0.5$ $Ne := \dfrac{D_w}{P_h}$ $Ne = 6$ $e := 1..Ne$ $h_e := \dfrac{\left(\frac{e}{2} - \frac{P_h}{2}\right)}{D_w}$

Lateral Soil pressure at the center of 0.5m^2 panels in relation to depth

$S\sigma_e := \sigma_{hs} \cdot h_e$

e =	h_e =	$S\sigma_e$ = ($m^{-2} \cdot 10^3$newton)
1	0.083	0.8
2	0.25	2.5
3	0.417	4.2
4	0.583	5.8
5	0.75	7.5
6	0.917	9.2

Lateral Water pressure at the center of of 0.5m^2 panels in relation to depth

$W\sigma_e := \sigma_{hw} \cdot h_e$

2.25 m Deep $W\sigma_1 := \sigma_{hw} \cdot \dfrac{2.25}{D_w \cdot 0.75}$ $W\sigma_1 = 1.1 \times 10^4\,m^{-2} \cdot newton$

1.75 m Deep $W\sigma_1 := \sigma_{hw} \cdot \dfrac{1.75}{D_w \cdot 0.75}$ $W\sigma_1 = 8.8 \times 10^3\,m^{-2} \cdot newton$

1.25 m Deep $W\sigma_1 := \sigma_{hw} \cdot \frac{1.25}{D_w \cdot 0.75}$ $W\sigma_1 = 6.3 \times 10^3 m^{-2} \cdot newton$

0.75 m Deep $W\sigma_1 := \sigma_{hw} \cdot \frac{0.75}{D_w \cdot 0.75}$ $W\sigma_1 = 3.8 \times 10^3 m^{-2} \cdot newton$

0.25 m Deep $W\sigma_1 := \sigma_{hw} \cdot \frac{0.25}{D_w \cdot 0.75}$ $W\sigma_1 = 1.3 \times 10^3 m^{-2} \cdot newton$

Uplift pressure - Concrete ring 150mm thick, internal radius 1.09m, concrete base 250mm thick

Internal block weight - 70 concrete blocks with steps - 0.44kN each

$W_b := 70 \cdot 0.44 \cdot 10^3 \cdot newton$ $W_b = 3.08 \times 10^4 \cdot newton$

$v_c := \left[\pi (1.25m)^2 \cdot D_w \cdot 1m - \pi (1.09m)^2 \cdot D_w \cdot 1m + \pi (1.25m)^2 \cdot 0.25m\right] \cdot Q_c + W_b$ $v_c = 1.4 \times 10^5 \cdot newton$

Water weight
assumed water level @ 0.75 cellar depth $W_l := 0.75 D_w \cdot m$ $W_l = 2.25 m$

$v_w := \pi (1.25m)^2 \cdot W_l \cdot 10 \times 10^3 \frac{N}{m^3}$ $v_w = 1.1 \times 10^5 \cdot newton$ OK

Safety factor $\frac{v_c}{v_w} = 1.31$. > 1.1 required by BS8007

Uniform Strip Load Case

The Lateral load from foundation at varying distances from the circular wall is given by the following.
Calculations assume that foundation is position 0.5m below top of the cellar.

Foundation outstand assumed as 150mm $Bc := 0.15$

Depth of $0.5m^2$ panels in meters $D_l := P_h$ $D_l = 0.5$

Amount of $0.5m^2$ panels in height of the cellar - Nd
and heights of the centers of panels - zi $N_d := \frac{(D_w - D_l)}{P_h}$ $N_d = 5$ $i := 1 .. N_d$

$z_i := \frac{i}{2} - \frac{P_h}{2}$

Depth zi measured from foundation level

i =	z_i =
1	0.25
2	0.75
3	1.25
4	1.75
5	2.25

Amount of $0.5m^2$ panels in quarter of cellar $Y := 3$ $k := 0 .. Y$ $\omega_k := \frac{\pi \cdot k}{8} + 22.5deg$

Angle increment in quarter of cellar

k =	ω_k = (·deg)
0	22.5
1	45
2	67.5

3 90

FOUNDATION - HORIZONTAL LOADS

Minimal horizontal perpendicular distance from foundation edge to the cellar center $a_1 := 1.4$

Distance from foundation edge to 0.5m^2 panel of cellar $x1_k := a_1 - Bc - r \cdot \sin(\omega_k)$

$x1_k =$

0.772
0.366
0.095
0

Foundation breadth $B1 := \frac{B}{1m}$ $B1 = 0.6$

Stress Calculations due to uniform strip load according to 'Basic Soil Mechanics' R.Whitlow - p.190

$$G1_{i,k} := \frac{(x1_k + B1)}{z_i} \qquad H1_{i,k} := \frac{x1_k}{z_i}$$

$$\beta1_{i,k} := \operatorname{atan}(G1_{i,k}) - \operatorname{atan}(H1_{i,k}) \qquad \alpha1_{i,k} := \operatorname{atan}(H1_{i,k})$$

$$\alpha1 = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 1.257 & 0.972 & 0.364 & 0 \\ 0.8 & 0.454 & 0.126 & 0 \\ 0.553 & 0.285 & 0.076 & 0 \\ 0.415 & 0.206 & 0.054 & 0 \\ 0.33 & 0.161 & 0.042 & 0 \end{pmatrix} \qquad \beta1 = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0.133 & 0.346 & 0.862 & 1.176 \\ 0.271 & 0.457 & 0.621 & 0.675 \\ 0.279 & 0.373 & 0.432 & 0.448 \\ 0.249 & 0.298 & 0.324 & 0.33 \\ 0.217 & 0.244 & 0.257 & 0.261 \end{pmatrix}$$

Influence factor

$$F1_{i,k} := \cos(\beta1_{i,k} + 2 \cdot \alpha1_{i,k}) \qquad E1_{i,k} := \sin(\beta1_{i,k})$$

$$I1_{i,k} := \frac{\beta1_{i,k} - E1_{i,k} \cdot F1_{i,k}}{\pi}$$

$$I1 = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0.08 & 0.181 & 0.279 & 0.261 \\ 0.111 & 0.117 & 0.079 & 0.06 \\ 0.073 & 0.051 & 0.026 & 0.018 \\ 0.042 & 0.024 & 0.011 & 0.007 \\ 0.025 & 0.013 & 0.006 & 0.004 \end{pmatrix}$$

Uniform Load $UL1 = 1.5 \times 10^5 m^{-2} \cdot newton$ $QUL1\Delta\sigma_{i,k} := UL1 \cdot I1_{i,k}$

$$QUL1\Delta\sigma = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 1.2\times10^4 & 2.7\times10^4 & 4.2\times10^4 & 3.9\times10^4 \\ 1.7\times10^4 & 1.7\times10^4 & 1.2\times10^4 & 8.9\times10^3 \\ 1.1\times10^4 & 7.6\times10^3 & 3.9\times10^3 & 2.7\times10^3 \\ 6.4\times10^3 & 3.6\times10^3 & 1.7\times10^3 & 1.1\times10^3 \\ 3.8\times10^3 & 1.9\times10^3 & 838.8 & 555.8 \end{pmatrix} m^{-2}\cdot newton$$

See attached Appendix for loads and design forces

Concrete design

Design for concrete according to BS EN889-2:2006-Fibres for Concrete and CE Technical Specification in Appendix 5.

Tensile Flexural Strength for C20 concrete with 5 kg/m3 strux 90/40 as additive $f_e := 1.5\cdot newton\cdot mm^{-2}$

Maximum Moment for 1m run of ring $M_r := 2.67\cdot 10^3 newton\cdot m$

See Appendix for finite element design

Section from cellar ring $b := 1m$

Thickness of ring wall $h_r := 0.150m$

Modulus section $W_r := \frac{b\cdot h_r^2}{6}$

$W_r = 0.00375\,m^3$

Ultimate Moment of resistance $M_{res} := f_e\cdot W_r$

$M_{res} = 5.63\times 10^3\, m\cdot newton$

>

$M_r = 2.67\times 10^3\, m\cdot newton$ OK

Use 5 kg/m3 Strux 90/40 additive for C30 concrete mix

Concrete design base

The following calculations ascertain the structural integrity of the proposed alterations to the above address.

Base pressure

Water weight - assume water level at full depth $W_l := 3m$ $W_l = 3\,m$

$v_w := \pi(1.25m)^2 \cdot W_l \cdot 10 \times 10^3 \dfrac{N}{m^3}$ $v_w = 1.473 \times 10^5 \cdot newton$

Design according to Engineering Bulletin from Grace Construction - See Appendix 2

Bending moment formula for circular slab based on Concrete Designer's Manual by E.Reynolds

Concrete with STRUX 90/40 Synthetic Fiber Reinforcement Design

Hand mix C30 is approximately C20

Tensile Flexural Strength for C20 concrete with 5 kg/m3 strux 90/40 as additive $f_e := 1.55 \cdot newton \cdot mm^{-2}$

See Table 1 in Appendix 2

Poisson's ratio $v := 0.2$

Base radius $r_b := 1.0m$

Base diamerer $d_b := 2 \cdot r_b$

Water load $v_w = 1.473 \times 10^5 \cdot newton$

Design load $B_p := \dfrac{v_w}{\pi \cdot r_b^2}$ $B_p = 4.69 \times 10^4\, m^{-2} \cdot newton$

Maximum Moment in the circular base per 1m run $M_b := \dfrac{B_p \cdot d_b^2}{64} \cdot (3 + v)$ $M_b = 9.38 \times 10^3 \cdot newton$

1m section fron ring $b := 1m$

Thickness of ring wall $h_r := 0.300m$

Modulus section $W_r := \dfrac{b \cdot h_r^2}{6}$ $W_r = 0.015\,m^3$

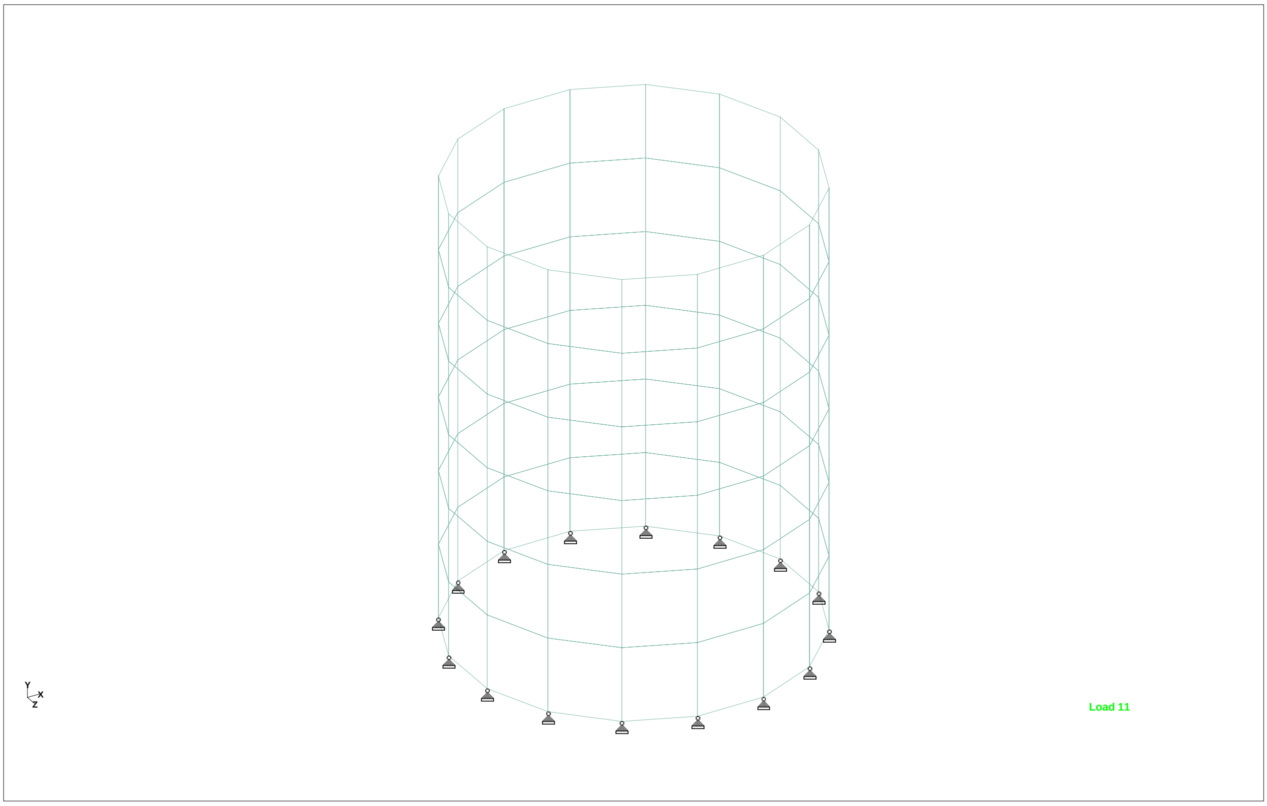
Ultimate Moment of resistance $M_{res} := f_e \cdot W_r$

$M_{res} = 2.33 \times 10^4\, m \cdot newton$ $M\,res > M\,b$

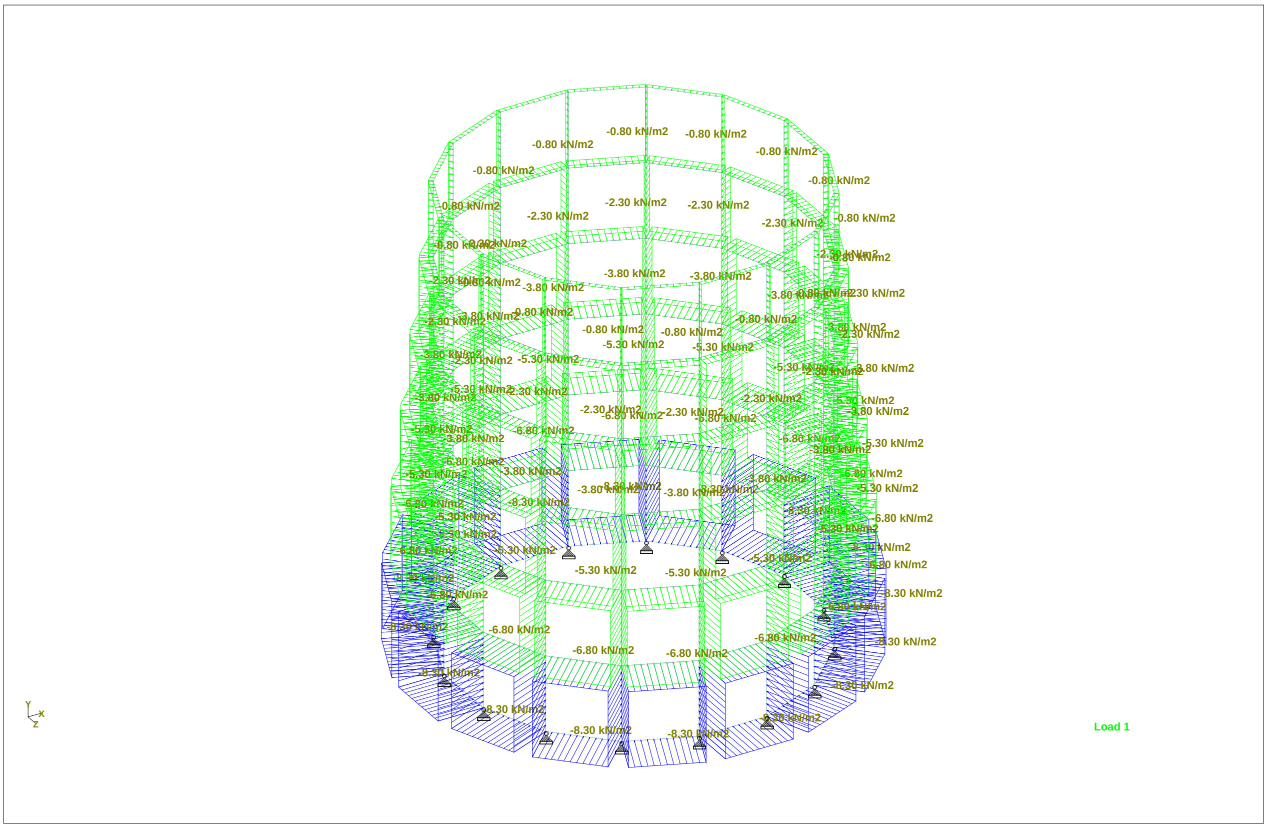
Use 5 kg/m3 Strux 90/40 additive for C30 concrete mix for 300mm concrete base

Appendix 1

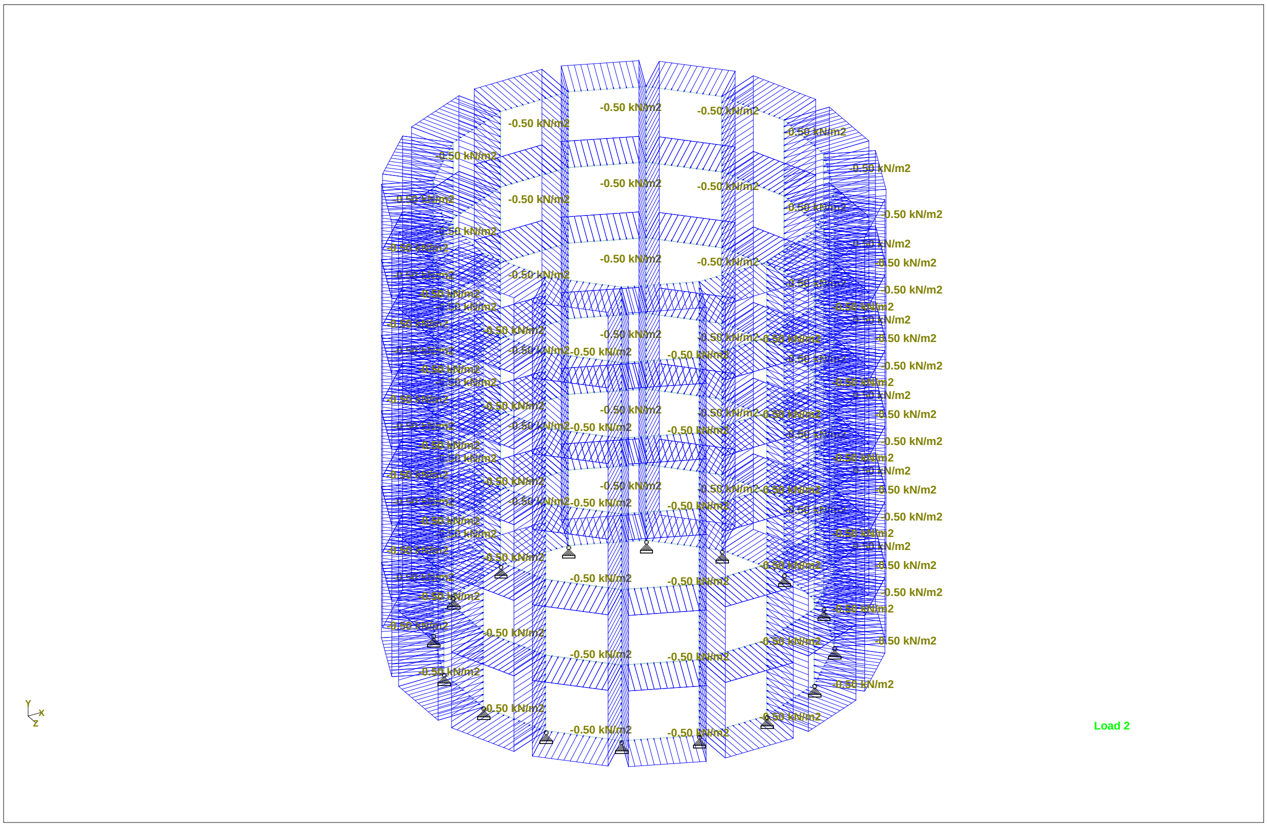
Finite Element Analysis



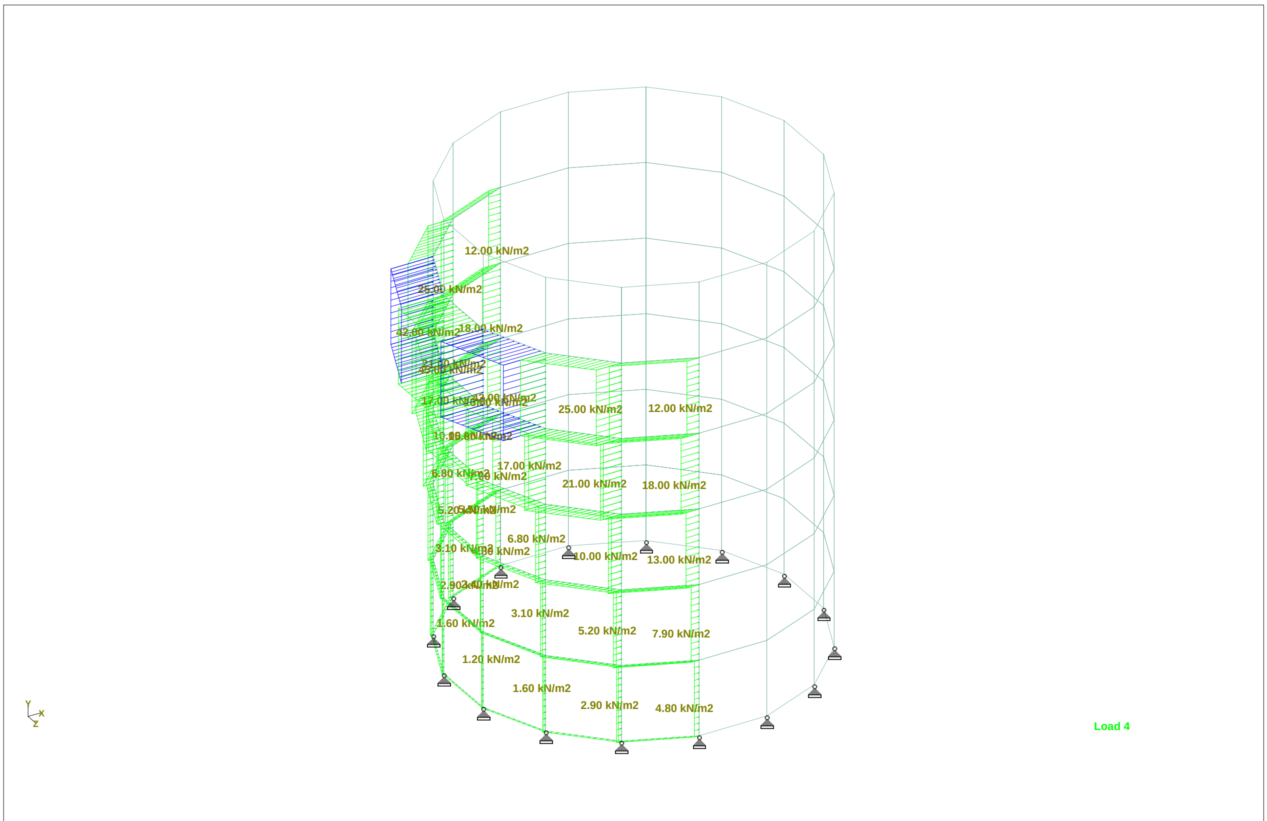
3.0m Deep Cellar



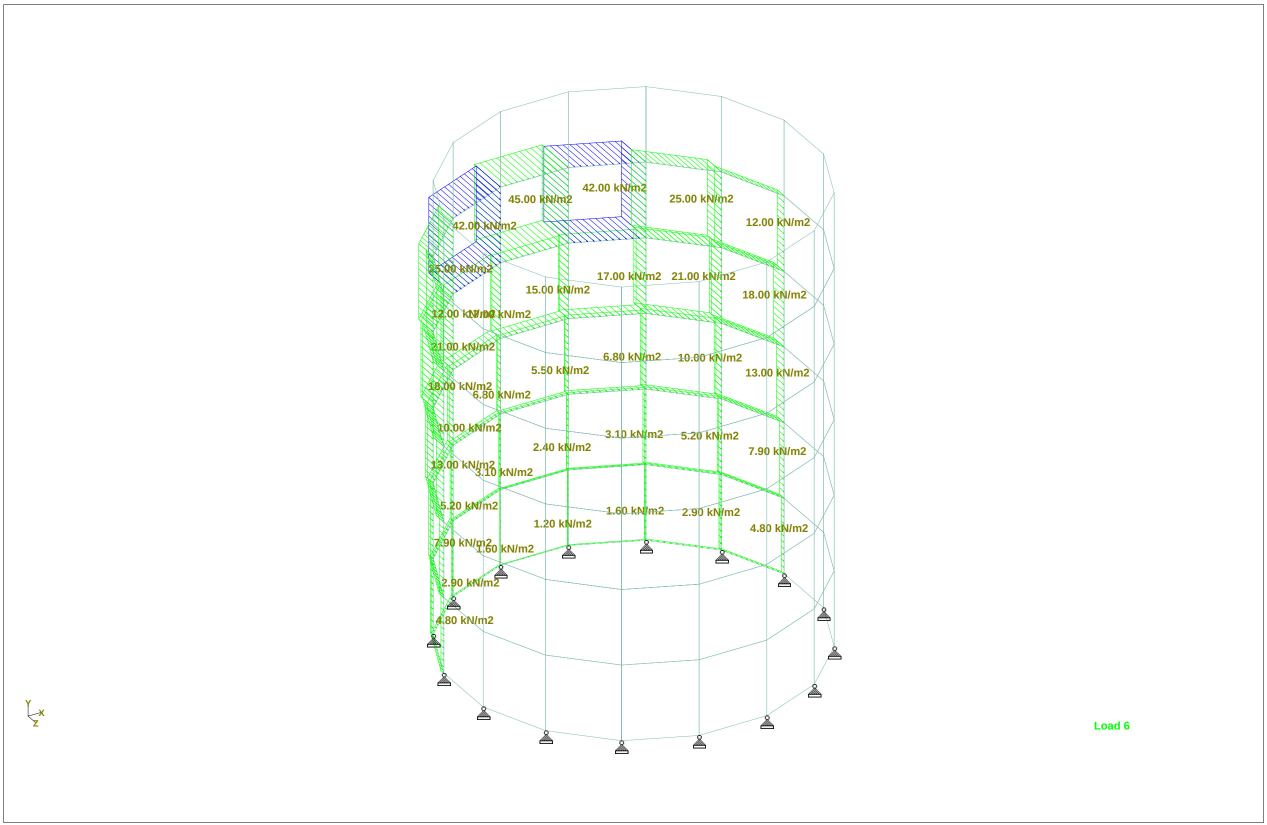
3.0m Deep Cellar – Soil Loads



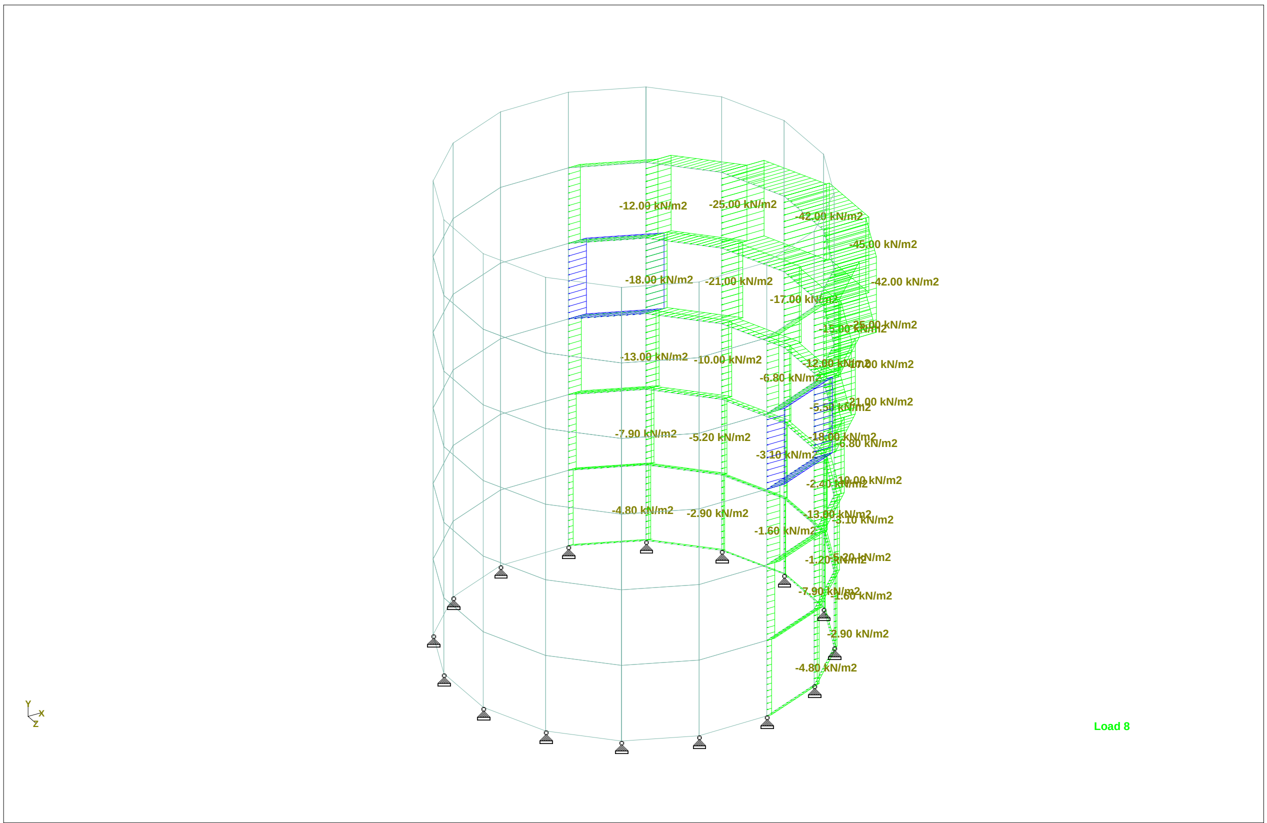
3.0m Deep Cellar – Live Loads – 0.5 kN/m2



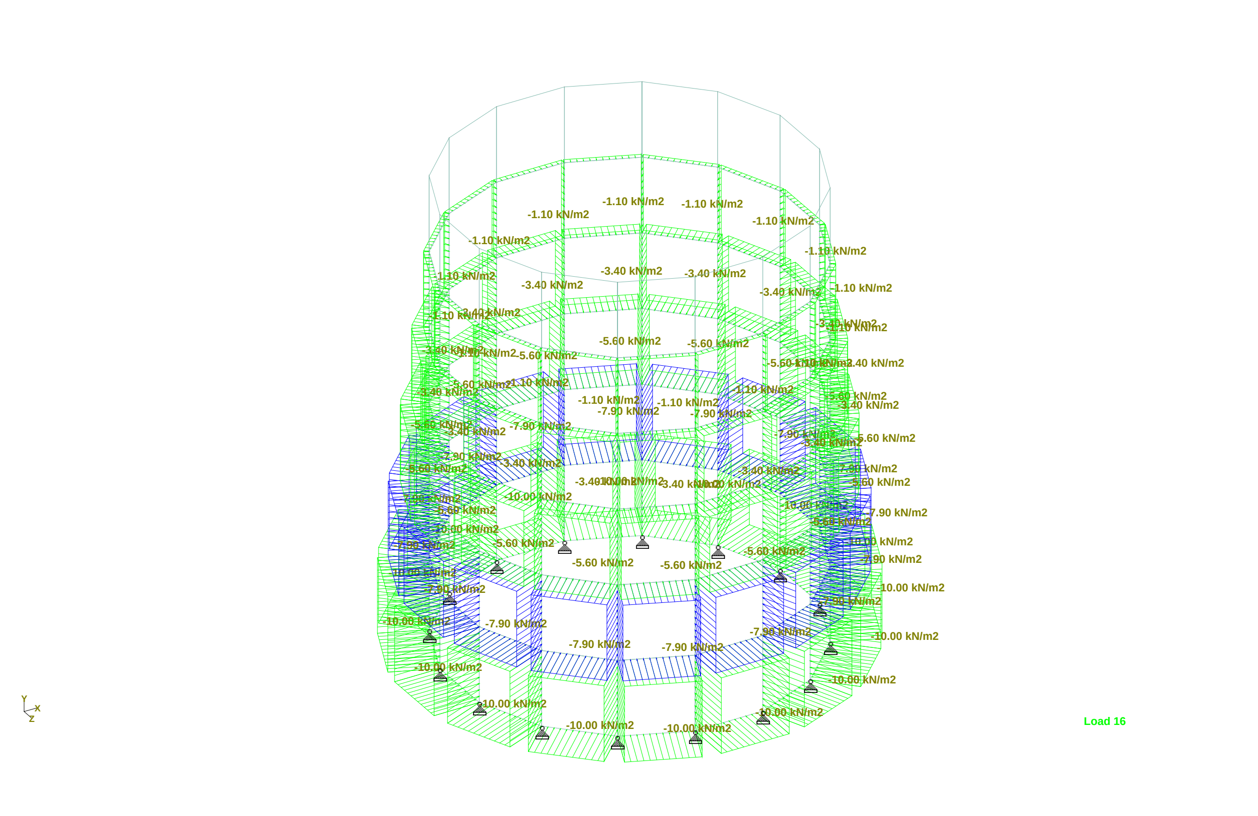
3.0m Deep Cellar – Wall 1 – Horizontal Loads



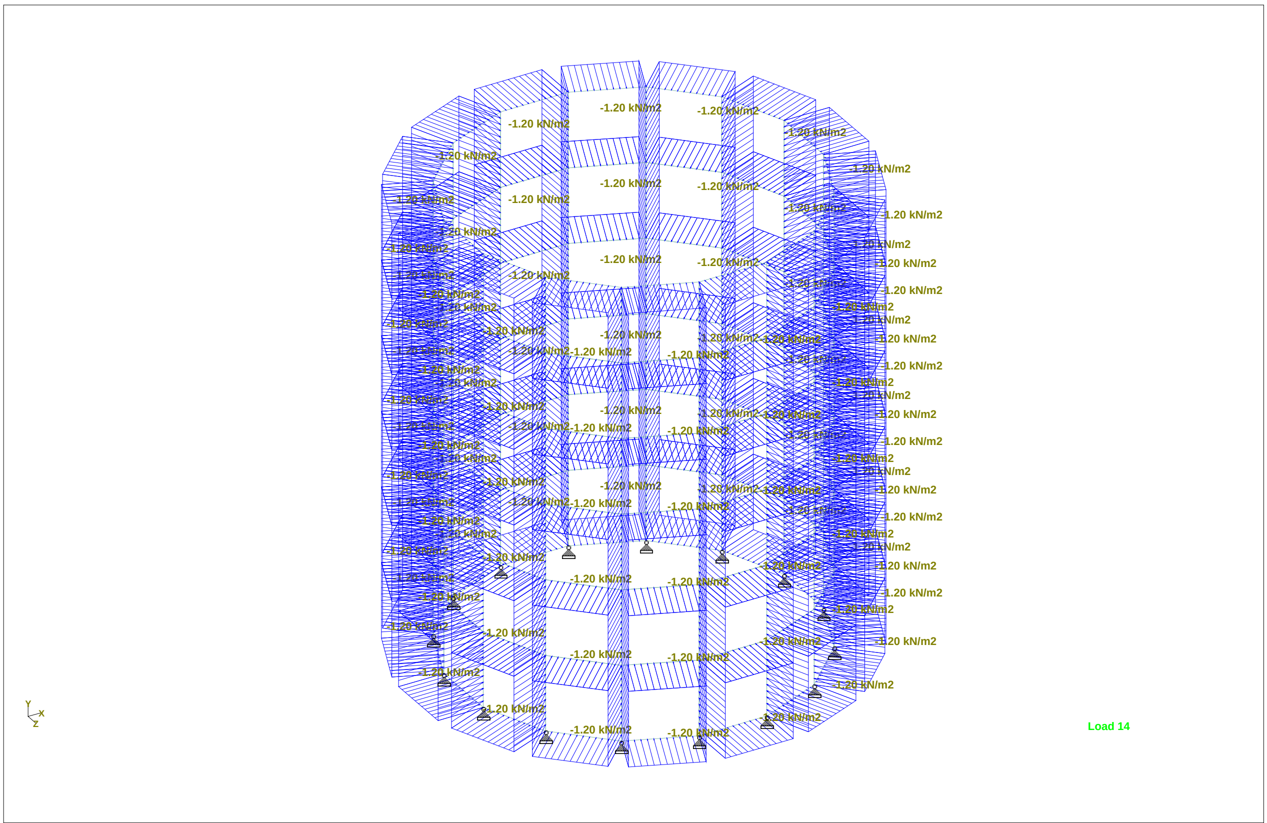
3.0m Deep Cellar – Wall 2 – Horizontal Loads



3.0m Deep Cellar – Wall 3 – Horizontal Loads



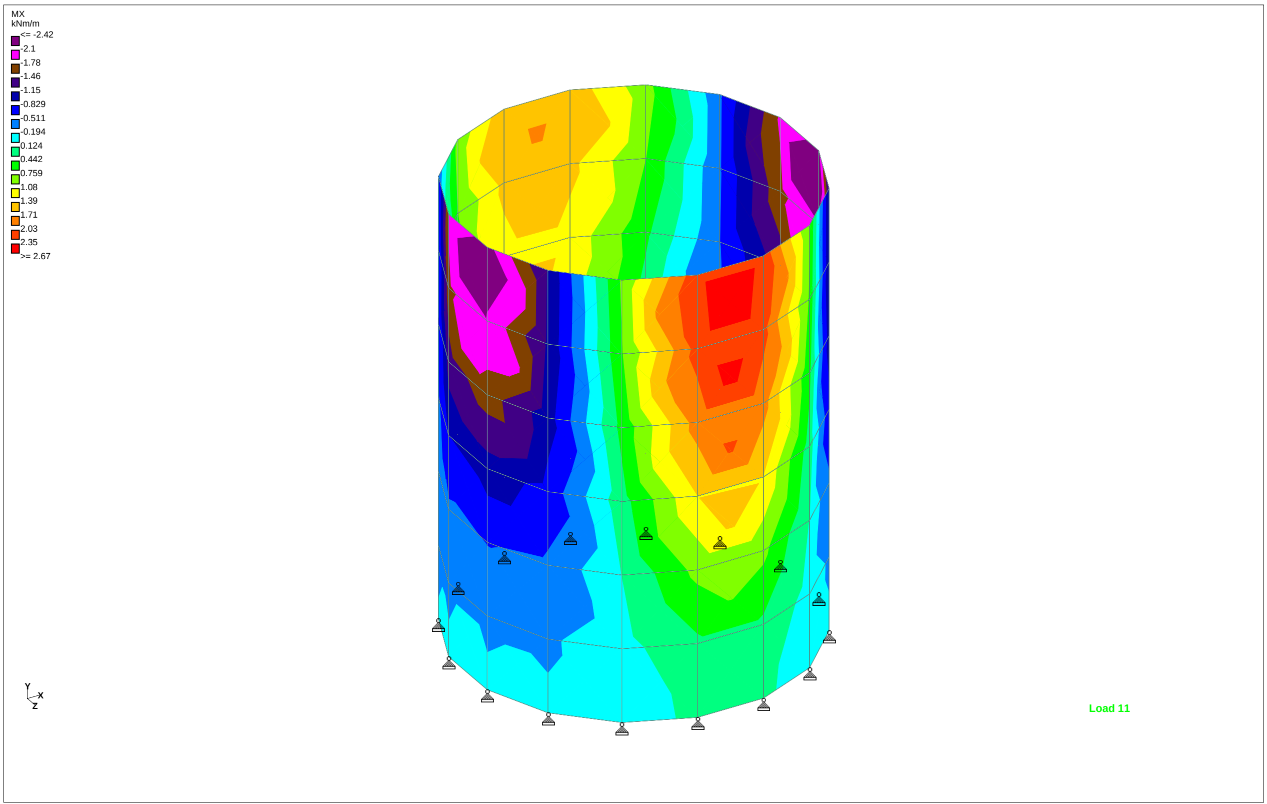
3.0m Deep Cellar – Lateral Water Loads



3.0m Deep Cellar – Surcharge – Concrete Floor

Combination Load Cases

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
11	COMBINATION WALL 1,2,3	2	SURCHARGE - LIVE LOADS	1.60
		1	SOIL	1.40
		3	SELF WEIGHT	1.40
		4	WALL 1 - LOADS	1.40
		16	WATER	1.40
		14	SURCHARGE - CONCRETE FLOOR	1.40
		6	WALL 2 - LOADS	1.40
		8	WALL 3 - LOADS	1.40
12	COMBINATION - UNFACTORED	1	SOIL	1.00
		2	SURCHARGE - LIVE LOADS	1.00
		3	SELF WEIGHT	1.00
		4	WALL 1 - LOADS	1.00
		6	WALL 2 - LOADS	1.00
		8	WALL 3 - LOADS	1.00
		16	WATER	1.00
		10	WALL 4 - LOADS	1.00
		14	SURCHARGE - CONCRETE FLOOR	1.00



3.0m Deep Cellar – Maximum Bending Moment due to Load Combination No 11

Plate Centre Stress Summary

	Plate	L/C	Shear		Membrane			Bending		
			Qx (kN/m^2)	Qy (kN/m^2)	Sx (kN/m^2)	Sy (kN/m^2)	Sxy (kN/m^2)	Mx (kNm/m)	My (kNm/m)	Mxy (kNm/m)
Max Qx	178	11:COMBINAT	**37.32**	1.48	-59.21	-8.09	-14.01	-0.209	-0.056	-0.189
Min Qx	182	11:COMBINAT	**-37.28**	1.56	-58.84	-8.16	13.99	-0.234	-0.058	0.190
Max Qy	192	11:COMBINAT	-8.82	**11.79**	-50.23	-16.63	10.26	-2.417	-0.442	0.039
Min Qy	160	11:COMBINAT	-7.21	**-15.55**	-313.83	0.61	138.97	-1.288	-0.360	0.045
Max Sx	183	11:COMBINAT	-21.27	9.20	**-39.66**	-15.75	6.72	-2.054	-0.345	0.129
Min Sx	172	11:COMBINAT	-0.08	0.77	**-401.34**	-21.15	0.56	1.564	-0.209	0.001
Max Sy	105	11:COMBINAT	-2.88	-6.29	-98.36	**266.54**	-152.41	-0.173	-0.236	-0.073
Min Sy	100	11:COMBINAT	-0.01	-6.17	-178.16	**-791.75**	-0.63	0.254	-0.232	0.002
Max Sxy	97	11:COMBINAT	-2.35	-4.50	-113.01	17.65	**322.76**	-0.157	-0.169	-0.108
Min Sxy	103	11:COMBINAT	2.37	-4.50	-112.74	22.44	**-320.14**	-0.157	-0.169	0.107
Max Mx	180	11:COMBINAT	-0.17	-7.51	-94.34	-3.65	0.07	**2.666**	0.282	0.001
Min Mx	192	11:COMBINAT	-8.82	11.79	-50.23	-16.63	10.26	**-2.417**	-0.442	0.039
Max My	164	11:COMBINAT	-0.17	-1.60	-166.55	-29.44	0.06	2.477	**0.623**	0.001
Min My	176	11:COMBINAT	-8.72	0.80	-294.58	-32.68	61.75	-2.032	**-0.914**	0.036
Max Mxy	150	11:COMBINAT	-23.87	-3.76	-209.01	-92.18	-190.84	-0.415	-0.130	**0.345**
Min Mxy	146	11:COMBINAT	24.00	-3.69	-208.38	-92.73	191.49	-0.397	-0.125	**-0.344**

Appendix 2

Concrete Mixing Specification

cement & concrete institute

Concrete, mortar & plaster mixes for builders

1. Large Batches

1.1 Concrete: Use only common cement complying with SANS 50197

Low-strength concrete suitable for: house foundations

Cement	Concrete Sand	Stone
1 Bag	$1\frac{3}{4}$ Wheelbarrows	$1\frac{3}{4}$ Wheelbarrows

To make 1 cubic metre of concrete you will need:

5,8 bags cement + 0,65 cubic metres sand + 0,65 cubic metres stone.

Medium-strength concrete suitable for: house floors, footpaths and driveways

Cement	Concrete Sand	Stone
1 Bag	$1\frac{1}{4}$ Wheelbarrows	$1\frac{1}{4}$ Wheelbarrows

To make 1 cubic metre of concrete you will need:

7,7 bags cement + 0,62 cubic metres sand + 0,62 cubic metres stone.

High-strength concrete suitable for: precast concrete, heavy-duty floors

Cement	Concrete Sand	Stone
1 Bag	1 Wheelbarrow	1 Wheelbarrow

To make 1 cubic metre of concrete you will need:

9,2 bags cement + 0,60 cubic metres sand + 0,60 cubic metres stone.

1.2 Mortar and Plaster: Using common cement complying with SANS 50197

Suitable for laying bricks and blocks in normal applications (SABS Class II)

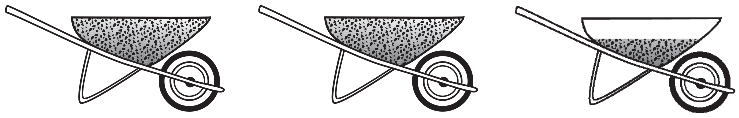
Cement	Building Sand (for mortar) or Plaster Sand (for plaster)
1 Bag	3 Wheelbarrows

Mortar: To lay 1 000 bricks you will need: 3 bags cement + 0,6 cubic metres sand.

Plaster: To plaster 100 square metres (15 millimeters thick) you will need: 12 bags cement + 2,3 cubic metres sand.

1.3 Mortar and Plaster: Using masonry cement complying with SANS 50413 class MC 22,5X or MC 12,5. Do not use grade MC 12,5X.

Suitable for exterior and interior work

Cement	Building Sand (for mortatr) or Plaster Sand (for plaster)
	
1 Bag	$2\frac{1}{2}$ Wheelbarrows

Mortar: To lay 1000 bricks you will need: 3,5 bags cement + 0,55 cubic metres sand.

Plaster: To plaster 100 square metres (15 millimetres thick) you will need: 14 bags cement + 2,25 cubic metres sand.

2. Small Batches

Use containers such as buckets, drums or tins.

Use the same size of container for measuring all the materials in a batch.

2.1 Concrete: Using common cement complying with SANS 50197

	Cement	Concrete Sand	Stone
Low-strength concrete	1	$3\frac{1}{2}$	$3\frac{1}{2}$
Medium-strength concrete	1	$2\frac{1}{2}$	$2\frac{1}{2}$
High-strength concrete	1	2	2

2.2 Mortar and Plaster: Using common cement complying with SANS 50197

Cement	Building Sand (for mortar) or Plaster Sand (for plaster)
1	5

2.3 Mortar and Plaster: Using masonry cement complying with SANS 50413

Cement	Building Sand (for mortar) or Plaster Sand (for plaster)
1	$4\frac{1}{2}$

Notes

1. The amount of water added to a mix must be enough to make the mix workable and plastic.
2. Use cement that has the SABS mark showing that it complies with SANS 50197 for all applications or masonry cement that complies with SANS 50413 for mortar and plaster.
3. Stone for concrete should be 19 mm or 26 mm size.
4. If you use a wheelbarrow for measuring, it should be a builder's wheelbarrow which has a capacity of 65 litres.

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cement & concrete institute

Trial Concrete Mixes:

proportions & quantities for ordering

Concrete strength at 28 days, MPa	Mass or volume	9,5 or 13,2 mm stone			19,0 or 26,5 mm stone		
		Cement	Sand	Stone	Cement	Sand	Stone
10	Mass/bag	50 kg	238 kg	128 kg	50 kg	230 kg	196 kg
	Volume/bag	**1 bag**	**0,175 m³**	**0,095 m³**	**1 bag**	**0,170 m³**	**0,145 m³**
	Mass/m³	250 kg	1 190 kg	640 kg	225 kg	1 030 kg	890 kg
	Volume/m³	5,0 bag	0,88 m³	0,47 m³	4,5 bag	0,76 m³	0,66 m³
15	Mass/bag	50 kg	175 kg	106 kg	50 kg	170 kg	164 kg
	Volume/bag	**1 bag**	**0,130 m³**	**0,080 m³**	**1 bag**	**0,125 m³**	**0,120 m³**
	Mass/m³	315 kg	1 100 kg	670 kg	280 kg	950 kg	920 kg
	Volume/m³	6,3 bag	0,82 m³	0,50 m³	5,6 bag	0,70 m³	0,68 m³
20	Mass/bag	50 kg	138 kg	92 kg	50 kg	130 kg	138 kg
	Volume/bag	**1 bag**	**0,100 m³**	**0,070 m³**	**1 bag**	**0,095 m³**	**0,100 m³**
	Mass/m³	375 kg	1 030 kg	690 kg	340 kg	880 kg	940 kg
	Volume/m³	7,5 bag	0,76 m³	0,51 m³	6,8 bag	0,65 m³	0,70 m³
25	Mass/bag	50 kg	114 kg	84 kg	50 kg	106 kg	125 kg
	Volume/bag	**1 bag**	**0,085 m³**	**0,060 m³**	**1 bag**	**0,080 m³**	**0,090 m³**
	Mass/m³	425 kg	970 kg	710 kg	385 kg	820 kg	960 kg
	Volume/m³	8,5 bag	0,72 m³	0,53 m³	7,7 bag	0,61 m³	0,71 m³
30	Mass/bag	50 kg	95 kg	78 kg	50 kg	90 kg	114 kg
	Volume/bag	**1 bag**	**0,070 m³**	**0,055 m³**	**1 bag**	**0,065 m³**	**0,085 m³**
	Mass/m³	475 kg	910 kg	730 kg	430 kg	770 kg	980 kg
	Volume/m³	9,5 bag	0,67 m³	0,54 m³	8,6 bag	0,57 m³	0,73 m³
35	Mass/bag	50 kg	80 kg	72 kg	50 kg	75 kg	105 kg
	Volume/bag	**1 bag**	**0,060 m³**	**0,055 m³**	**1 bag**	**0,055 m³**	**0,080 m³**
	Mass/m³	525 kg	850 kg	750 kg	475 kg	710 kg	1 000 kg
	Volume/m³	10,5 bag	0,63 m³	0,56 m³	9,5 bag	0,53 m³	0,74 m³
40	Mass/bag	50 kg	68 kg	68 kg	50 kg	64 kg	98 kg
	Volume/bag	**1 bag**	**0,050 m³**	**0,050 m³**	**1 bag**	**0,045 m³**	**0,075 m³**
	Mass/m³	575 kg	780 kg	770 kg	520 kg	650 kg	1 020 kg
	Volume/m³	11,5 bag	0,58 m³	0,57 m³	10,4 bag	0,49 m³	0,76 m³

For notes see over.

Notes

- Recommended concrete strengths for various uses are shown in the table below.

Concrete strength at 28 days, MPa	Use
10	Mass filling
15	Foundations for houses
20	Floors on the ground (surface beds) for houses
25	Reinforced concrete Home driveways
30	Reinforced concrete Floors on the ground for heavy duty – eg factories Farm roads
35	Floors on the ground for heavy duty – eg factories Precast concrete
40	Precast concrete

- Mix proportions in the table overleaf are based on the assumption that a CEM II/A 32,5 cement will be used. CEM I 42,5 or higher cements will give a stronger concrete but may be less economical. Cements with higher extender contents (eg CEM II/B or CEM III) will develop strength more slowly and will require particular care with curing. Masonry cements complying with SABS ENV 413-1 are **not recommended** for use in concrete.

- The amount of water required is not given in the table. The mix should contain enough water to achieve the required consistence. Consistence may be assessed by eye or measured by carrying out the slump test (SABS Method 862-1:1994). Recommended slumps are:

  50–100 mm for compaction by mechanical vibration

  100–150 mm for compaction by hand

- 0,001 m^3 = 1 litre

  The capacity of a builder's wheelbarrow is 65 litres.

- A mix made according to this table, and to the required consistence, should be assessed for stone content before being used on a large scale. This can be done by compacting some of the concrete in a container, eg a bucket, by the means (vibration or hand tamping) to be used on the job.

  If stones protrude from the surface, stone content is too high.

  If not, scratch the surface of the compacted concrete (before it hardens) with a nail or screwdriver. If the stone content is right, stones should be found two or three millimetres below the surface. If they are deeper than this, the stone content is too low.

  If stone content is too high, reduce it by 10 % and increase sand content by the same amount, ie volume or mass. Then reassess.

  If stone content is too low, increase it by 10 % and reduce sand content by the same amount, ie volume or mass. Then reassess.

- The mix proportions given in the table overleaf are conservative. If the quantity of concrete to be made exceeds about 100 m^3, it is probably possible to save costs by selecting materials and having a mix designed. For information on the choice of materials consult the C&CI.

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Appendix 3

Damp Proof Membrane Technical Specification

TABLEAU DES RESISTANCES AUX PRODUITS CHIMIQUES

1 : Résistant 2 : Résistant pour usage non continu 3 : Ne convient pas

PRODUITS	CONC. %	TEMP. °C	GEOBUTYL	EPDM	BUTALIM	POLYBLEND	FISHPOND
Acétaldehyde		TA	1	1	1	3	1
Acétate d'amyle		TA	2	2	2	3	2
Acétate de méthyle		TA	2	2	2	3	2
Acétate de méthylglycol		50	1		1	3	
Acétate d'éthyle		TA	2	1	2	3	1
Acétone		TA	1	1	1	3	1
Acétyl chlorure							
Acétylène			1		1	1	
Acide acétique	10	50	2	3	2	3	3
Acide arsenique				1			1
Acide benzoïque							
Acide borique	10	100	1	1	1	1	1
Acide bromhydrique	37	TA	1	1	1	3	1
Acide chlorhydrique	10	100	2	3	2	3	3
Acide citrique	SAT	70	1	1	1	1	1
Acide chromique	40	50	3	3	3	3	3
Acide cyanhydrique	20		1	1	1	3	1
Acide fluorhydrique	48	TA	1	1	1	3	1
Acide fluorosilicique	50		3	2	3		2
Acide formique	SAT	TA	1	2	1	2	2
Acide formique	SAT	70	2	2	2	3	2
Acide gallique			1	2	1	3	2
Acide hypochloreux			2	3	2	3	3
Acide lactique		70	1	1	1	1	1
Acide nitrique dilué	10	50	1	1	1	2	1
Acide oléique		TA	3	3	3	1	3
Acide oxalique	25	70	1	1	1	3	1
Acide palmitique			2	2	2	1	2
Acide phosphorique	60	50	1	1	1	3	1
Acide salicylique			1	1	1	1	1
Acide stéarique		70	3	2	3	2	2
Acide sulfurique	10	100	1	1	1	3	1
Acide tannique			1	1	1	1	1
Acide tartrique	10	100	1	2	1	1	2
Acrylate de butyl		50	3	3	3	3	3
Alcool amylique (pentanol)		50	1	1	1	2	1
Alcool benzylique		TA	2	1	2	3	1
Air		100	1	1	1		1

PRODUITS	CONC. %	TEMP. °C	GEOBUTYL	EPDM	BUTALIM	POLYBLEND	FISHPOND
Ammoniaque anhydre		TA	1	1	1	1	1
Ammoniaque liquide		TA	2	1	2	1	1
Anhydride acétique		TA	2	2	2	3	2
Aniline		TA	2	1	2	3	1
Azote			1	1	1	1	1
Benzène		TA	3	3	3	3	3
Benzoate d'éthyl			2	2	2		2
Beurre		100	3	3	3	3	3
Bicarbonate de soude			1	1	1	1	1
Butanol		50	2	1	2	1	1
Butyl amine		TA	3	3	3	3	3
Carbonate d'ammonium	SAT	70	1	1	1	3	1
Carbonate de soude	20	100	1	1	1	1	1
Castor oil		100	1	1	1	2	1
Chlore			3	3	3		3
Chloroacétone			3	1	3	3	1
Chloroforme		TA	3	3	3	3	3
Coconut oil			2	2	2	1	2
Créosote			3	3	3	2	3
Diacétone alcool			1	1	1	3	1
Dibenzyl éther		TA	1	2	1	3	2
Dibutyl aminé			3	3	3	3	3
Dichlorure de soufre			3		3	3	
Diéthylbenzène			3	3	3	3	3
Diéthylène glycol		100	1	1	1	1	1
Diisocyanate de toluène		70	1	1	1		1
Diméthyl aniline		TA	2	2	2	3	2
Dioctyl sébacate		TA	2	2	2	3	2
Dioxyde de chlore			3	3	3	3	3
Dioxyde de soufre		TA	2	1	2	3	1
Disulphure de carbone		TA	3	3	3	3	3
Eau chlorée		TA	3	3	3	3	3
Eau déminéralisée		100	1	1	1	1	1
Eau régale		TA	3		3	3	
Ethanol		50	1	1	1	1	1
Ethanolaminé (mono)		70	1	1	1	1	1
Ethyl cellulosé			2		2	1	
Ethylène glycol		100	1	1	1	1	1

TA = Température ambiante
SAT = Saturation

CHEMICALS	CONC. %	TEMP. °C	GEOBUTYL	EPDM	BUTALIM	POLYBLEND	FISHPOND
Formaldéhyde	40	TA	1		1	1	
Formaldéhyde	40	70				3	
Fréon 11		TA	3	3	3	1	3
Fréon 12		TA	1	2	1	1	2
Fréon 13 B1		TA	1	1	1	1	1
Fréon 21		TA	3	3	3	3	3
Fréon 22		TA	1	1	1	3	1
Fréon 31		TA	1	1	1	3	1
Fréon 32		TA	1	1	1	1	1
Fréon 112		TA	3	3	3	2	3
Fréon 113		TA	3	3	3	1	3
Fréon 114		TA	1	1	1	1	1
Fréon 114 B2		TA	3	3	3	2	3
Fréon 115		TA	1	1	1	1	1
Fréon 142 b		TA	1	1	1	1	1
Fréon 152 a		TA	1	1	1	1	1
Fréon 218		TA	1	1	1	1	1
Fréon C 316		TA	1	1	1	1	1
Fréon C 318		TA	1	1	1	1	1
Fréon TA			1	1	1	1	1
Fréon TF			3	3	3	3	3
Fréon T-P 35			1	1	1	1	1
Fréon T-WD 602			1	2	1	2	2
Fuel B 70 % isooctane		TA	3	3	3	2	3
Fuel C 50 % isooctane		TA	3	3	3	2	3
Fuel oil pour moteurs diesel		70	3	3	3	1	3
Gaz de pétrole liquifié			3	3	3	1	3
Gaz naturel			3	3	3	1	3
Glucose			1	1	1	1	1
Glycérine		100	1	1	1	1	1
Glycolmonoétherbutyl			1	1	1	1	1
Goudron bitumineux			3	3	3	2	3
Graisse de silicone			1	1	1	1	1
Hexanol		TA	2	3	2	1	3
Huile animale		50	2	2	2	1	2
Huile de lin		70	1	1	1	1	1
Huile de silicone			1	1	1	1	1
Huile de soja		TA	3	3	3	1	3
Huile d'olive		50	2	3	2	1	3
Huile lubrifiante n° 2 (graissage)		100	3	3	3	1	3
Huile minérale n° 1		100	3	3	3	1	3
Huile minérale n° 2		100	3	3	3	1	3
Huile minérale n° 3		100	3	3	3	1	3
Huile pour transformateurs			3	3	3	1	3
Huiles végétales			2	2	2	1	2

CHEMICALS	CONC. %	TEMP. °C	GEOBUTYL	EPDM	BUTALIM	POLYBLEND	FISHPOND
Hydrazine			1	1	1	2	1
Hydrogène			1		1	1	
Hydroquinone						3	
Hydroxyde d'ammonium	10	TA	1	1	1	1	1
Hydroxyde de calcium		100	1		1	2	
Hydroxyde de soude	10	100	1	1	1	1	1
Hypochlorite de calcium	15		1	1	1	3	1
Hypochlorite de soude	10	50	1	1	1	2	1
Iodoforme			1	1	1		1
Isobutanol		TA	1	1	1	2	1
Iso-octane (fuel A)		TA	3	3	3	1	3
Isopropanol			1	1	1	2	1
Kérosène		70	3		3	1	
Lait			1	1	1	1	1
Lard		70	2	3	2	1	3
Liquide de freins (végétale)		50	1	1	1	3	1
Mercure			1		1	1	
Méthane			3	3	3	1	3
Méthanol		50	1	1	1	1	1
Mono vinyl acétylène		-20	1	1	1		1
Monoxyde de carbone		50	1	1	1	1	1
Nitro benzène		50	1	1	1	3	1
Octanol			1	1	1	2	1
Oxygène		TA	1	1	1	1	1
Oxygène liquide			1		1	3	
Péroxyde de sodium			1	1	1		1
Phénol		100	2	2	2	3	2
Propane liquide			3	3	3	1	3
Propanol		50	1	1	1	2	1
Sels organiques et leurs solutions	SAT	70	1	1	1	1	1
Skydrol 500		70	2	1	2	3	1
Skydrol 7000		70	2	1	2	3	1
Solution de saccharose			1	1	1	1	1
Solution savonneuse			1	1	1	1	1
Soufre			1	1	1	3	1
Sulfate de plomb			1	1	1	2	1
Tétrachlorure de carbone		TA	3	3	3	3	3
Thérébentine		TA	3	3	3	1	3
Tributyl phosphate		100	3	1	3	3	1
Trichlorure phosphoreux			1	1	1	3	1
Tricrésyl phosphate		70	1	1	1	3	1
Triaryl phosphate			1	1	1	3	1
Vapeur			1	1	1	1	1
Ypérite			1	3	1		3

TA = Température ambiante
SAT = Saturation

PRODUCT SPECIFICATION - UNIVEX BUTYL

PHYSICAL PROPERTIES	UNIT	REQUIREMENTS	TYPICAL VALUE	TEST METHODS
Hardness	°IRH	65 ± 5	69	ISO 48
Tensile strength	MPa	min 8,5	9,7	ISO 37
Elongation at break	%	min 350	460	ISO 37
Tear strength	kN/m	min 20	26	ISO 34
Foldability at low temperature	°C	max -40	-40	EN 495-5

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BUTYL RUBBER SPECIFICATION

Typical Properties	Test Method	Specification (Typical Values)	Minimum Values
Tensile Strength	BS 903 Part A2	8.0 MPa	7.0 MPa
Modules at 300%	BS 903 Part A2	5.5 MPa	4.5 MPa
Elongation at Break	BS 903 Part A2	350%	300%
Tear Strength	BS 903 Part A3	30 N/mm	25N/mm
Ozone Resistance (7 days/50pphm/30 Deg C)	BS 903 Part A43 Procedure A		50% extensions No cracks
Heat Aging (Retentions) (7 days @ 100 .Deg. C)	BS 903 Part A19	6.0 MPa 250%	5.6 MPa 200%
Flex Cracking	BS 903 Part A10		200.000 cycles, no crack
Specific Gravity	BS 903 Part A1	1.24 +/- 0.03	
Nominal Weight	@ 1mm thickness	1240 g/m^2	
Dimensional Stability	1 Hr at 100 .Deg C	+/- 1% Max	

Grade AA Agrement Board Certificate No 87/1884

Thickness Available 0.75mm 1.0mm & 1.5mm, Reinforced materials 1.0mm thick

Form 112 Rev. A

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CHEMICAL RESISTANCE OF BUTYL RUBBER

A – Recommended B – Minor Effect

Acetaldehyde	A	Acetamide	A	Acetic Acid, 30%	B
Acetic Acid, Glacial	B	Acetic Anhydride	B	Acetone	A
Acetophenone	A	Acetylene	A	Aluminium Acetate	A
Aluminium Chloride	A	Aluminium Fluoride	A	Aluminium Nitrate	A
Aluminium Phosphate	A	Aluminium Sulphate	A	Ammonia Anhydrous	A
Ammonia Gas (Cold)	A	Ammonia Gas (Hot)	B	Ammonium Carbonate	A
Ammonium Chloride	A	Ammonium Hydroxide	A	Ammonium Persulphate	A
Ammonium Nitrate	A	Ammonium Phosphate	A	Ammonium Sulphate	A
Amyl Acetate	A	Amyl Alcohol	A	Aniline	B
Aniline Dyes	B	Aniline Hydrochloride	B	Animal Fats	B
Arsenic Acid	A				
Barium Chloride	A	Barium Hydroxide	A	Barium Sulphate	A
Barium Sulphide	A	Beer	A	Beet Sugar Liquors	A
Benzaldehyde	A	Benzoic Acid	A	Benzyl Alcohol	B
Benzyl Benzoate	B	Bleach Solutions	A	Borax	A
Bordeaux Mixture	A	Boric Acid	A	Brine	A
Butter	B	Butyl Acetate	B	Butyl Acetyl Ricinoleate	A
Butyl Alcohol	B	Butyl Benzoate	A	Butyl Carbitol	A
Butyl Cellosolve	A	Butyl Oleate	B	Butyl Stearate	B
Butyraldehyde	B				
Calcium Acetate	A	Calcium Chloride	A	Calcium Hydroxide	A
Calcium Hypochlorite	A	Calcium Nitrate	A	Calcium Sulphide	A
Cane Sugar Liquors	A	Carbamate	B	Carbitol	B
Carbolic Acid	B	Carbon Dioxide	A	Carbon Monoxide	A
Carbonic Acid	A	Caster Oil	B	Cellosolve	B
Cellosolve Acetate	B	Cellulube	A	Chloroacetic Acid	B
Chloroacetone	B	Chlorobromomethane	B	Citric Acid	A
Cobalt Chloride	A	Coconut Oil	A	Cod Liver Oil	A
Copper Acetate	A	Copper Chloride	A	Copper Cyanide	A
Copper Sulphate	A	Corn Oil	B	Cyclohexanone	B
Denatured Alcohol	A	Detergent Solutions	A	Developing Fluids	B
Diacetone	A	Diacetone Alcohol	A	Dibenzyl Ether	B
Dibenzyl Sebecate	B	Dibutyl Phthalate	B	Dibutyl Sebecate	B
Diethlamine	B	Diethyl Sebecate	B	Diethylene Glycol	A
Diisopropyl Ketone	A	Dimethyl Phthalate	B	Dioctyl Phthalate	B
Dioctyl Sebecate	B	Dioxane	B		
Epichlorohydrin	B	Ethanolamine	B	Ethyl Acetate	B
Ethyl Acetoacetate	B	Ethyl Acrylate	B	Ethyl Alcohol	A
Ethyl Benzoate	B	Ethyl Cellosolve	B	Ethyl Cellulose	B
Ethyl Oxalate	A	Ethylene Diamine	A	Ethyl Chloride	A
Ethyl Formate	B	Ethyl Silicate	A	Ethylene Glycol	A

Ferric Chloride	A	Ferric Nitrate	A	Ferric Sulphate	A
Fluorinated Cyclic Ethers	A	Fluoroboric Acid	A	Fluorocarbon Oils	A
Fluorolube	A	Fluosilicic Acid	A	Formaldehyde	A
Formic Acid	A	Freon 12	B	Freon 13	A
Freon 13B1	A	Freon 22	A	Freon 31	A
Freon 32	A	Freon 114	A	Freon 115	A
Freon 142b	A	Freon 152a	A	Freon 502	A
Freon C316	A	Freon C318	A	Freon TA	A
Freon TC	A	Freon TMC	B	Freon T-P35	A
Freon T-WD602	A	Fufural	B		
Gallic Acid	B	Gelatin	A	Glauber's Salt	B
Glycerin	A	Glycols	A	Glucose	A
Glue	A	Green Sulphate Liquor	A		
n-Hexaldehyde	B	Hydrazine	A	Hydrobromic Acid	A
Hydrochloric Acid (cold)	A	Hypochlorous Acid	B	Hydrocyanic Acid	A
Hydrofluoric Acid-Anhydrous	B	Hydrofluoric Acid (Conc.) Cold	B	Hydrofluosilicic Acid	A
Hydrogen Gas	A	Hydrogen Suphide (wet)(Cold)	A	Hydrogen Suphide (wet)(Hot)	A
Iodoform	A	Isobutyl Alcohol	A	Isophorone	A
Isopropyl Acetate	A	Isopropyl Alcohol	A		
Lactic Acid	A	Lead Acetate	A	Lead Nitrate	A
Lead Sulphamate	A	Lime Bleach	A	Lime Sulphur	A
Lindol	A	Linseed Oil	B	Lye	A
Magnesium Chloride	A	Magnesium Hydroxide	A	Mercuric Chloride	A
Mercury	A	Mesityl Oxide	B	Methyl Acetate	B
Methyl Acrylate	B	Methyl Alcohol	A	Methyl Butyl Ketone	A
Methyl Cellosolve	B	Methyl Formate	B	Methyl Oleate	B
Methyl Salicylate	B	Methylacrylic Acid	B	Milk	A
Monoethanolamine	B	Monovinyl Acetylene	A	Mustard Gas	A
Neatsfoot Oil	B	Neville Acid	B	Nickel Acetate	A
Nickel Chloride	A	Nickel Sulphate	A	Niter Cake	A
Nitric Acid-Dilute	B	Nitroethane	B	Nitrogen	A
Nitromethane	B				
Octyl Alcohol	A	Oleic Acid	B	Olive Oil	B
Oxalic Acid	A	Oxygen – Cold	A	Ozone	B
Palmitic Acid	B	Perchloric Acid	B	Phenol	B
Phophorous Trichloride	A	Phorone	B	Phosphoric Acid – 20%	A
Phosphoric Acid – 45%	B	Picric Acid	B	Plating Solution-Chrome	A
Plating Solution-Others	A	Polyvinyl Acetate – Emulsion	A	Potassium Acetate	A
Potassium Chloride	A	Potassium Cupro Cyanide	A	Potassium Cyanide	A
Potassium Dichromate	A	Potassium Hydroxide	A	Potassium Nitrate	A
Potassium Sulphate	A	Propyl Acetate	B	n-Propyl Acetate	A
Propyl Alcohol	A	Propyl Nitrate	B	Propylene Oxide	B
Pydrauls	B	Pyridine	B	Pyroligneous Acid	B
Rapeseed Oil	A				

Sal Ammoniac	A	Salicylic Acid	A	Salt Water	A
Sewage	B	Silicone Greases	A	Silicone Oils	A
Silver Nitrate	A	Skydrol 500	B	Skydrol 7000	A
Soap Solutions	A	Soda Ash	A	Sodium Acetate	A
Sodium Bicarbonate	A	Sodium Bisulphite	A	Sodium Borate	A
Sodium Chloride	A	Sodium Cyanide	A	Sodium Hydroxide	A
Sodium Hypochlorite	B	Sodium Metaphosphate	A	Sodium Nitrate	A
Sodium Perborate	A	Sodium Peroxide	A	Sodium Phosphate	A
Sodium Silicate	A	Sodium Sulphate	A	Sodium Thiosulphate	A
Stannic(ous) Chloride	B	Steam Under 300ºF	A	Sucrose Solution	A
Sulphite Liquors	B	Sulphur	A	Sulphur Dioxide	B
Sulphur Hexafluoride	A	Sulphur Trioxide	B	Sulphuric Acid (Dilute)	B
Sulphuric Acid (Conc)	B	Sulphurous Acid	B		
Tannic Acid	A	Tartaric Acid	B	Tertiary Butyl Alcohol	B
Tertiary Butyl Catechol	B	Tetrabutyl Titanate	B	Tetrhydrofuran	B
Triacetin	A	Triaryl Phosphate	A	Tributoxy Ethyl Phosphate	A
Tributyl Phosphate	A	Trichloroacetic Acid	B	Tricresyl Phosphate	A
Triethanol Amine	B	Trioctyl Phosphate	A	Toluene Diisocyanate	A
Unsymmetrical Dimethyl Hydrazine (udmh)	A				
Vegetable Oils	A	Versilube	A	Vinegar	A
Wagner 21B Fluid	B	Water	A	Whisky, Wines	A
Zeolites	A	Zinc Acetate	A	Zinc Chloride	A
Zinc Sulphate	A				

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Geotextile High Puncture Resistance

Liner Protection Material

Properties	Test Method	Typical Values
Weight	EN 965	250 g/m^2
Thickness	EN 964-1 2kPa	2.3mm
CBR Puncture Resistance	EN ISO 12236	3000N
Tensile Strength (average values)	EN ISO 10319 md xd	16.6 kN/m 18.3 kN/m
Elongation	EN ISO 10319 md xd	50% 55%
Cone drop test	EN 918	13Mm
Pore size	ENISO 12956	90um
Water flow rate	ENISO 11058	85 $L/m^2.s$

Colour:Black

Appendix 4

CE Technical Specification for Strux 90-40

STRUX® 90/40

SYNTHETIC MACRO FIBRE REINFORCEMENT

www.graceconstruction.com

CE 1077

UK

Grace Bauprodukte GmbH
Pyrmonter Strasse 56
32676 Luegde - Germany
Plant II

Date of delivery note

1077-CPD-U393

EN 14889-2

Polymer fibres for concrete

Polymer type: Polypropylene/Polyethylene

Class II

Length: 40 mm

Equivalent diameter: 0,433 mm

Shape: cross sectional area rectangular

Tensile strength: 620 N/mm²

Elastic modulus: 9500 N/mm²

Effect on consistence with 3,5 kg/m³ fibres:
Vebe time: 10s (Reference concrete: 7s)

Effect on strength of concrete:
3,5 kg/m³ to obtain 1,5 N/mm² at CMOD=0,5 mm and 1 N/mm² at CMOD=3,5 mm.

DE

Grace Bauprodukte GmbH
Pyrmonter Strasse 56
32676 Luegde - Germany
Werk II

Datum des Lieferscheins

1077-BPR-U393

EN 14889-2

Polymerfasern für Beton

Polymerart: Polypropylen/Polyethylen

Klasse II

Länge: 40 mm

Äquivalenter Durchmesser: 0,433 mm

Form: Querschnitt rechteckig

Zugfestigkeit: 620 N/mm²

Elastizitätsmodul: 9500 N/mm²

Einfluss auf Konsistenz mit 3,5 kg/m³ Fasern:
Vebe Zeit: 10s (Referenzbeton: 7s)

Einfluss auf die Festigkeit von Beton:
3,5 kg/m³ für 1,5 N/mm² bei CMOD=0,5 mm und 1 N/mm² bei CMOD=3,5 mm

FR

Grace Bauprodukte GmbH
Pyrmonter Strasse 56
32676 Luegde - Germany
Plant II

Date de livraison

1077-DCP-U393

EN 14889-2

Fibres de polymère pour béton

Nature de polymère: Polypropylène/Polyéthylène

Classe II

Longueur: 40 mm

Diamètre équivalent: 0,433 mm

Forme: Section transversale rectangulaire

Résistance à la traction: 620 N/mm²

Module d'élasticité: 9500 N/mm²

Consistence avec 3,5 kg/m³ des fibres:
temps Vebe: 10s (Beton temoins: 7s)

Incidenc sur la résistance du béton :
3,5 kg/m³ pour obtenier 1,5 N/mm² pour CMOD=0,5 mm et 1 N/mm² pour CMOD=3,5 mm

IT

Grace Bauprodukte GmbH
Pyrmonter Strasse 56
32676 Luegde - Germany
Plant II

Data bolla di consegna

1077-CDP-U393

EN 14889-2

Fibre polimeriche per calcestruzzo

Tipo di Polimero : Polipropilene/Polietilene

Classe II

Lunghezza: 40 mm

Diametro equivalente: 0,433 mm

Forma: sezione trasversale: rettangolare

Resistenza alla Trazione: 620 N/mm²

Modulo di Elasticità: 9500 N/mm²

Effetto sulla consistenza con 3,5 kg/m³ di fibre:
Vebe tempo: 10s (Calcestruzzo di riferimento: 7s)

Effetto sulla resistenze del calcestruzzo:
3,5 kg/m³ per ottenere 1,5 N/mm² con CMOD=0,5 mm e 1 N/mm² con CMOD=3,5 mm

ES

Grace Bauprodukte GmbH
Pyrmonter Strasse 56
32676 Luegde - Germany
Plant II

Fecha del albarán de entrega

1077-CPD-U393

EN 14889-2

Fibras poliméricas para hormigón

Tipo de polímero: Polipropileno/Polietileno

Clase II

Longitud: 40 mm

Diámetro (equivalente): 0,433 mm

Forma: sección transversal rectángular

Resistencia a la tracción: 620 N/mm²

Módulo elástico: 9500 N/mm²

Consistencia con 3,5 kg/m³ de fibras:
tiempo Vebe: 10 s (hormigón de referencia: 7 s)

Efecto sobre la resistencia del hormigón:
3,5 kg/m³ para obtener 1,5 N/mm² a CMOD=0,5 mm y 1 N/mm² a CMOD=3,5 mm.

Appendix 5

Reinforced Synthetic Fibres STRUX 90/40
Engineering Bulletin

Concrete

ENGINEERING BULLETIN

STRUX® 90/40
FIBER REINFORCEMENT

Strength-Based Analysis to Replace Steel with STRUX 90/40 Synthetic Fibers in SOG Flooring - SI Units

The use of structural synthetic fibres as a replacement for steel reinforcement in flooring is becoming more accepted due to their various advantages: tight crack control, easy use, safe handling, scheduling advances, and no corrosion.

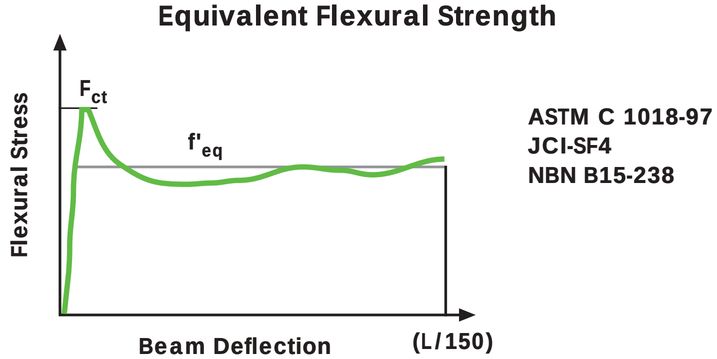
It is, however, important to ensure that the level of reinforcement offered by the structural synthetic fibres is in fact equivalent to that of the steel reinforcement that is being replaced. This document addresses the calculation of recommended STRUX(r) 90/40 dosage rates matching the level of reinforcement by various types of welded wire mesh and light rebar in slab-on-ground (SOG) applications.

It is well recognized that the addition of fibres improves concrete properties including ductility, fracture toughness and crack control. The improvement in the residual strength or the post-cracking strength of fibre reinforced concrete is presented as the equivalent flexural strength, fe3, which was initially developed by the Japanese Concrete Institute (JCI-SF4). This approach later became widely accepted by other standards such as the American Society for Testing and Materials (ASTM), RILEM, and the British Standards Institute (BSI). The fe3 must be determined on a beam with a 150 mm x 150 mm cross-section and a length of at least 500 mm (6 in. x 6 in. x 20 in.) tested according to ASTM C 1018-97 up to a beam deflection of 3 mm (0.12 in.).

ASTM C 1399, ASTM C 1018, JCI-SF4 and RILEM TC-162 determine the post cracking strength or residual strength of fiber reinforced concrete assuming a linear elastic behavior. This implies that the post-cracking strength of fibre reinforced concrete can be easily calculated using the equivalent flexural strength determined from the bending test specified in standard tests. The equivalent flexural strength is determined from a load-deflection curve obtained in bending of beams (See JCI-SF4). Figure 1 shows that the equivalent flexural strength, feq, is calculated to have the same area as the area under load deflection curve obtained from testing. This equivalent flexural strength is a strength parameter which characterizes the post-cracking resistance. Therefore, it can be used for design and stress analysis of fibre reinforced concrete structures. Table 1 shows the equivalent flexural strength of STRUX 90/40 reinforced concrete at different fibre dosage rates and different concrete strengths.

Fibres control cracking in a much better way than steel mesh or secondary reinforcing bars (temperature and shrinkage steel)

Figure 1
Equivalent Flexural Strength



Equivalent Strength: Indicated by the same toughness obtained from experiment to a deflection of L/150 (same area under load-deflection)

Patent Pending

GRACE Construction Products

Table 1

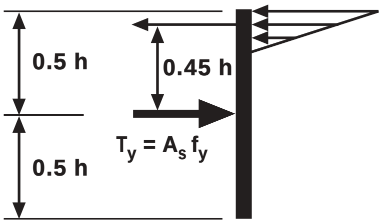
Equivalent Flexural Strength, $f_{e,3}$, for Different Dosage Rates and Concrete Strengths

STRUX 90/40	Compressive Strength (MPa)					
kg/m^3	20	25	30	35	40	50
2.0	0.74	0.82	0.90	0.99	1.07	1.24
2.5	0.87	0.96	1.04	1.12	1.21	1.37
3.0	1.01	1.09	1.17	1.26	1.34	1.51
3.5	1.14	1.23	1.31	1.39	1.48	1.64
4.0	1.28	1.36	1.45	1.53	1.61	1.78
4.5	1.41	1.50	1.58	1.66	1.75	1.92
5.0	1.55	1.63	1.72	1.80	1.88	2.05
5.5	1.68	1.77	1.85	1.94	2.02	2.19

because fibres interfere with the cracking phenomenon at its inception and arrest microcracks and prevent them from becoming macrocracks. Furthermore, the distribution of fibres makes it more efficient to control cracking. In order to replace the steel mesh with fibres while maintaining the same performance, fibre reinforced concrete must have the same post-cracking. Grace has developed conversion tables for STRUX 90/40 based on experimental tests, engineering analysis and calculations. The technical approach and some examples are presented to illustrate the replacement of steel reinforcement with STRUX 90/40.

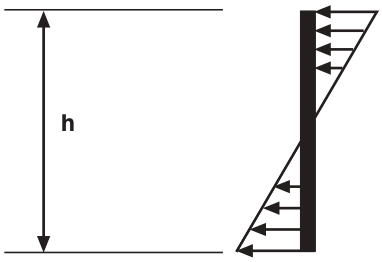
The criterion used herein is that both the steel reinforced concrete section and the fibre reinforced concrete section must have equal post-cracking strength. The post-cracking strength is defined as the flexural capacity of the concrete section after cracking. Using the strain-compatibility method, ultimate post-cracking flexural capacity with steel mesh at mid depth, Mu, is given by the following equation:

$$M_u = A_s f_y\,(0.45bh)$$



Where As is the area of steel per unit length, fy is the yield stress of the steel, b is the unit width and h is the thickness of the concrete section. The ultimate post-cracking flexural capacity of the fiber reinforced concrete wall is given by:

$$M_u = f'_{eq}\,\frac{bh^2}{6}$$



Where f'eq is the equivalent flexural strength of the fibre reinforced concrete (tested according to ASTM C 1018-97 and calculated as described before). The equivalent flexural strength depends primarily on the type of fibres and the dosage rates at which they are added to the concrete. Furthermore, Grace has found that it also depends on the strength of the concrete. Grace has performed extensive laboratory testing to cover the compressive strength range of practical interest (i.e. concrete strength 15 to 50 MPa). A summary of the equivalent flexural strength is presented in Table 1.

To replace the steel reinforcement with fibres, the fibres must be added such that the moment capacities for the steel reinforced and for the fibre reinforced concrete are equal as follows:

$$M_u = A_s f_y\,(0.45bh) = f'_{eq}\,\frac{bh^2}{6}$$

The equivalent flexural strength can then be calculated to match the required level of reinforcement. Having calculated the equivalent flexural strength, the fibre dosage rate is determined to produce the required level of post-cracking strength for the concrete class under consideration. The calculation used to develop the conversion table assumed the yield stress of the steel as 400 MPa. Some examples illustrating the calculation are presented herein.

Minimum Dosage

As it is the case for any reinforced concrete section, a minimum reinforcement must be satisfied even if the strength calculation does not require reinforcement. For fibre reinforced concrete, the minimum fibre dosage rate shall control cracking. The minimum dosage rate depends on the strength of the concrete. The higher the strength of the concrete, the higher the required minimum dosage. This is due to the fact that higher strength concrete stores more elastic energy before cracking occurs. When the stored elastic energy is released upon cracking, the fibres must be able to absorb the released elastic energy to keep the crack width small.

Therefore, the minimum dosage rate for STRUX 90/40 has been specified to satisfy this condition. The dosage rate for STRUX 90/40 should not fall below the minimum specified in the conversion tables if tight crack control has to be achieved.

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